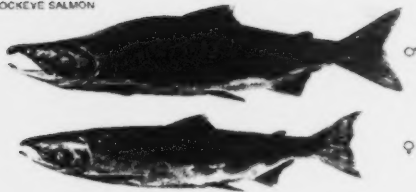# RUN RECONSTRUCTION AND ESCAPEMENT GOALS
FOR ALSEK RIVER SOCKEYE SALMON

SOCKEYE SALMON

Sockeye salmon adult spawning phase. DFO website.
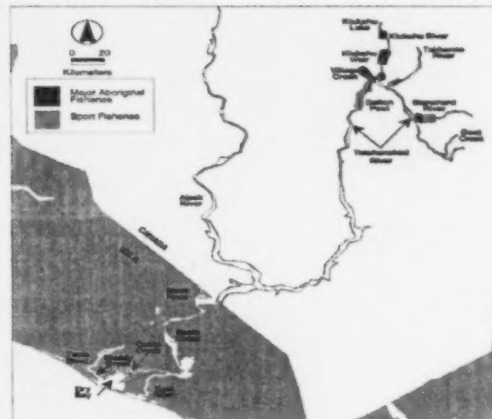

Figure 1: Watershed of the Alsek River with locations of fisheries and sampling identified

Context:

The Alsek River is considered a "transboundary" system; one which rises in Canada and flows to the ocean through the United States. Management of salmon originating in the Alsek River is done so through agreements outlined in the Transboundary chapter (Annex IX) of the Pacific Salmon Treaty (PST). Biologically based escapement goals form the basis for management decisions related to transboundary stocks.

Currently, only the Klukshu River (an Alsek tributary) has a PST accepted escapement goal (7,500 – 15,000 Sockeye salmon), based on analyses conducted in 2000. The PST Transboundary agreement (2010) commits to establishing updated biologically based escapement goals for both the Alsek and Klukshu Rivers, and to review of the proposed escapement goals by both the Transboundary Technical Committee (TCC) and the Salmon Standing Committee of the Centre for Science Advice Pacific (CSAP).

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Pacific Regional Advisory Process. Additional publications resulting from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Canadä

SUMMARY

- Alsek River Sockeye, including those sockeye returning to its tributary the Klukshu River, are considered a single Conservation Unit under the Wild Salmon Policy. Management of this stock is conducted bilaterally through the Pacific Salmon Treaty (PST).

- The Salmon Standing committee of the Centre for Science Advice Pacific (CSAP) was presented updated analysis and results conducted by the Alaskan Department of Fish and Game (ADF&G) regarding the optimal escapement goals for Alsek and Klukshu River Sockeye salmon.

- Escapement and run reconstruction analysis incorporated stock assessment data from 1976 to 2008. Data and methods in the current analysis are considered an improvement over methods employed previously and take into account known sources of uncertainty.

- Bayesian analysis of data resulted in a posterior distribution for *Smsy* (spawning abundance needed to produce maximum sustained yield) with a mean of 29,710 sockeye and a median of 28,190 sockeye for the Alsek stock. Posterior distributions for *Smsy* for the Klukshu stock had a mean of 9,727 adults and a median of 9,102 adults.

- A range of optimal escapement goals, based on 60, 70, 80 or 90 % probability of achieving *Smsy,* is provided; allowing managers to make an informed decision when establishing escapement targets.

- Escapement goal ranges of 24,000 to 33,500 adults for the Alsek River and 7,500 to 11,000 adults for the Klukshu River were proffered in the reviewed report. These escapement ranges represented a 90-96% and a 79-90% chance of achieving at least 90% of MSY for the Alsek and Klukshu River's, respectively.

- Given the incorporation of uncertainty in stock assessment data and the robust approach used to provide advice on the establishment of escapement goals, it is recommend that the methods used in this assessment be considered when providing escapement goal advice for other Canadian systems, where appropriate given the data available.

BACKGROUND

The Alsek River drains approximately 19,000 km^2 of Alaska and Canada into the Gulf of Alaska at 59° 11' N 138° 29' W (Figure 1). The river is home to all five species of Pacific salmon; with sockeye migrating from May to October. Sockeye salmon are harvested in commercial and subsistence set gillnet fisheries below the border in the U.S. portion of the Alsek River and in U.S. surf waters near the terminus of the Alsek River. Harvests from the commercial fishery are enumerated from fish tickets (sales receipts issued to fishers from processors when their catches are sold). Commercial harvests are considered a census with no sampling error

Numeric escapement information for sockeye salmon spawning in the Klukshu River is annually obtained by Fisheries and Oceans Canada (DFO) staff with the aid of a weir constructed across the lower portion of the Klukshu River. Counts of sockeye salmon as they pass the Klukshu River weir have been made each year since 1976. DFO provides estimates of the number of sockeye salmon that spawn each year by subtracting from the weir counts the estimated upstream catches and brood stock removals. These annual estimates provide a continuous database of monitored annual escapements to the Klukshu River system. There is some degree of uncertainty in the annual Klukshu sockeye salmon escapement estimates due to the uncertainty in the fishery catch above the weir. However, in most years (particularly since 1980), removals are relatively small in comparison to weir counts so the escapement estimates, in many cases, represent almost a complete census and sampling error is relatively low. The

run of sockeye salmon at the Klukshu weir is very protracted, beginning in late June and continuing through late October. Inspection of daily weir counts from 1976–2008, shows a very consistent temporal pattern of weir counts between years.

Rationale for Assessment

The current PST recommended and accepted escapement goal range of 7,500 to 15,000 sockeye salmon spawning in the Klukshu River was produced in 2000.

Annex IV of the 2008 Pacific Salmon Treaty Bilateral Agreement directs the parties to continue to develop and implement abundance based management programs for Alsek River sockeye salmon. Specifically, Chapter 1, Paragraph 2(c)(i) of Annex IV of the Pacific Salmon Treaty Bilateral Agreement adopted in 2008 states: "The Parties will continue to develop and implement cooperative abundance-based management programs for Alsek River sockeye salmon including agreed above border spawning escapement and management goals for Chinook and sockeye salmon. The Parties agree to develop joint technical reports and submit them through the various Parties' review mechanisms. The aim is to identify and establish a revised bilaterally agreed to maximum sustained yield (MSY) escapement goal for Alsek Chinook and sockeye salmon prior to the 2014 fishing season that will be used until another agreed goal is developed."

The PST Transboundary agreement (2010) re-affirms this commitment with the agreement that the review of proposed escapement goals be undertaken by both the Transboundary Technical Committee and CSAP.

ANALYSIS

Bayesian statistical analysis of the catch and escapement data available for Alsek and Klukshu River was used to reconstruct runs and to determine optimum escapement goals for the Alsek sockeye stock because 1) information on relative age composition is missing for some years, 2) estimates of spawning abundance contain considerable measurement error, and 3) such an analysis provides an expression of the uncertainty associated with the chosen escapement goal. This approach follows closely that used by Bernard and Jones (2010) in analysis of Alsek River Chinook salmon stock productivity. This expression of uncertainty is in the form of posterior probability distributions for parameters and variables given the observations of the Alsek stock made since 1976. Some observations (estimates and data) are considered known without error while others were considered to be stochastic with assumed or estimated levels of measurement error. Rates, parameters, and variables defining states are considered to be unknown, but with an uncertainty expressible through probability distributions.

A two-stage approach was used; first, a Bayesian run reconstruction model was used to estimate the posterior distributions of the historical run components (Alsek in-river run, Klukshu in-river run, and U.S. catch). In the second stage, a Bayesian stock-recruit model was used to estimate seven desired reference points, where the posterior distributions of the reconstructed components of the Alsek run (expressed as log normal posteriors with respective mean and variance) were provided as input to the Bayesian simulations.

Alsek River

Simulations resulted in a posterior distribution for the variable *Seq* (Spawning abundance associated with carrying capacity) with a mean of 73,320 and a median of 69,830 adults for the Alsek stock. The median value of MSY from its posterior distribution is 39,220 adults.

The expected value for the average of spawning escapements from the stock-recruit model over years 1976–2008 (49,600 adults) compares favorably to the 1976–2008 mean of the calendar year posterior distribution from the run reconstruction model simulations (51,800 adults).

The average escapement is below the mean (73,300 adults) of the posterior distribution for carrying capacity (the variable SEQ), consistent with the exploitation history of the stock. The average total harvest rate (U.S. fishery + Canadian food and sport fishery) on this stock is 37%.

Optimum yield (OY) profiles for the Alsek stock are given in Figure 2 (upper panel). For convenience, OY was defined as a sustained yield that was at least 60%, 70%, 80%, or 90% of MSY. A range of 24,000 to 33,500 spawners was used to demonstrate how to establish a specific goal. The probability of achieving OY if escapements are kept within this range is 90% to 96%, given that OY is defined as at least 90% of MSY. The probability of achieving OY was capped at 96% because there was no escapement that was bracketed by optimum ranges in all MCMC samples. The probability of achieving a less stringent (80% of MSY) standard for OY at this range reaches near certainty at 97% to 100%. For the 60% and 70% MSY standard, the range of 24,000 to 33,500 spawners was within the optimum ranges in virtually all simulations.

Overfishing profiles for the Alsek stock show that an escapement of 24,000 spawners runs a 10% risk of recruitment overfishing if OY is based on ≥90% of MSY (Figure 2 – lower panel). As expected, that risk is less (3%) when OY is at least 80% of MSY and virtually nil under less stringent standards for OY.

A biological escapement goal of 24,000 to 33,500 spawners per year was recommended by the Standing Committee for the Alsek River sockeye salmon stock. This range of escapement is expected to produce yields close to MSY (≥90% of MSY) with 90% to 96% probability. This range carries with it a reasonable expectation of MSY and was estimated with explicit consideration of uncertainties in the data (measurement error) and in the productivity of the resource (process error). This range meets the common standard of OY used by ADF&G (≥90% of MSY), and meets the requirements for a Biological Escapement Goal (BEG) under the State of Alaska's Sustainable Salmon Fishery Policy (5 AAC 39.222).
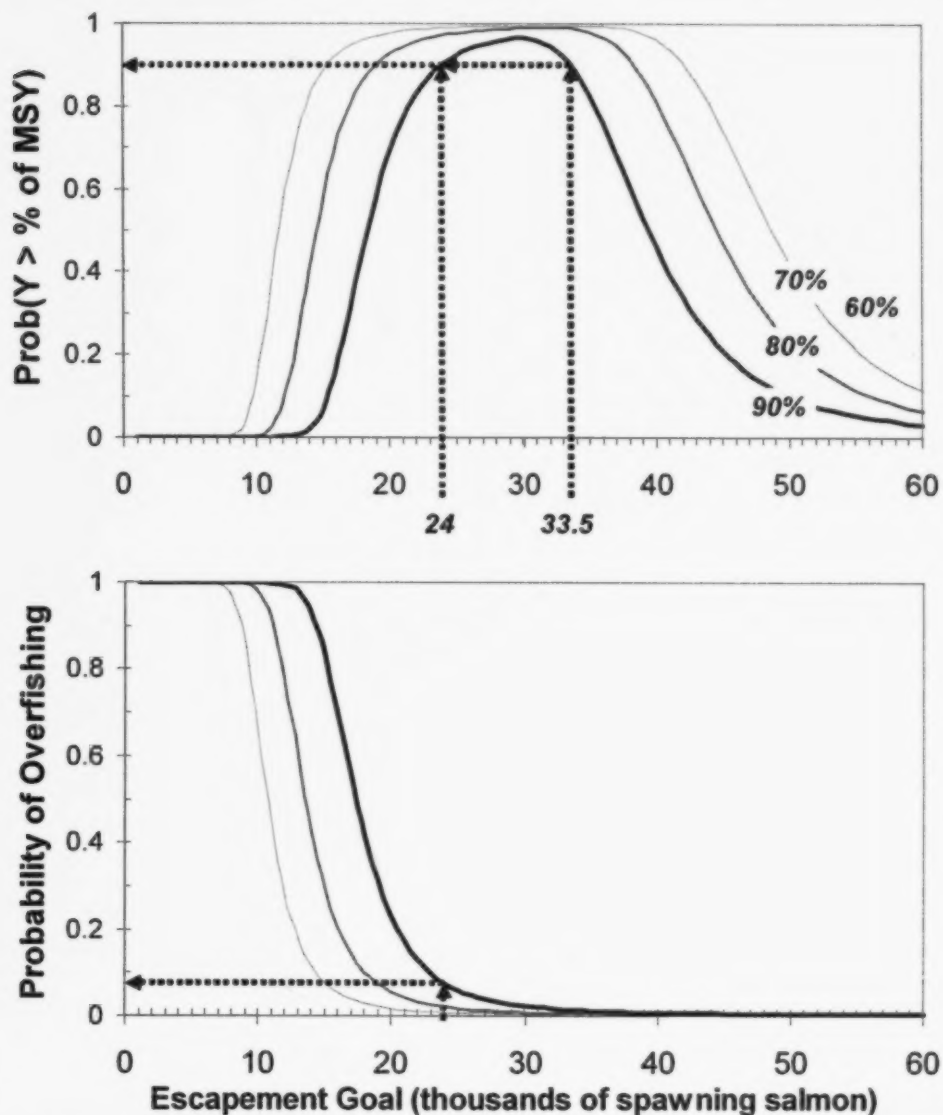
Figure 2. Upper Panel: optimum yield (OY) profiles defined as probability of at least Y percent of maximum sustained yield (MSY) at potential escapement goals for the Alsek River stock. Shown are profiles for 60%, 70%, 80% and 90% of MSY. Dashed lines on the 90% OY profile connect the range of escapements (24 to 33.5 thousand) that provide 90% percent of MSY with probability 0.9. Lower panel: over fishing (OF) profiles defined as the probability of having less than Y percent of optimum yield through recruitment over fishing at that escapement level. Shown are profiles corresponding to 60%, 70%, 80%, and 90% of MSY.

Klukshu River

Simulations resulted in a posterior distribution for the variable S_{msy} with a mean of 9,727 and a median of 9,102 adults for the Klukshu stock. The median value of MSY from its posterior distribution is 15,980 adults. The expected value for the average of spawning escapements from the Klukshu stock-recruit model over years 1976–2008 (14,250) compares favorably to the 1976–2008 mean of the calendar year posterior distribution from the run reconstruction model simulations (14,283 adults). The average escapement is well below the mean (24,250 adults) of the posterior distribution for carrying capacity (the variable SEQ), consistent with the exploitation history of the stock. The average U.S. fishery annual harvest on this stock is 27.2% across the years. Optimum yield profiles for the Klukshu stock are given in Figure 3 (upper panel). For convenience OY was defined as a sustained yield that was at least 60%, 70%, 80%, or 90% of MSY.

A range of 7,500 to 11,000 spawners was used to demonstrate how to establish a specific goal. The probability of achieving OY if escapements are kept within this range is 79% to 90%, given that OY is defined as at least 90% of MSY. The probability of achieving OY was capped at 90% because there was no escapement that was bracketed by optimum ranges in all MCMC samples. The probability of achieving a less stringent (80% of MSY) standard for OY at this range reaches near certainty at 95% to 96%. Overfishing profiles for the Klukshu stock show that an escapement of 7,500 adults runs a 15% risk of recruitment overfishing if OY is based on ≥90% of MSY (Figure 3 - lower panel). As expected, that risk is less (4.7%) when OY is at least 80% of MSY and virtually nil under less stringent standards for OY.

A biological escapement goal range of 7,500 to 11,000 spawners per year was recommended by the authors for the Klukshu River sockeye salmon stock.
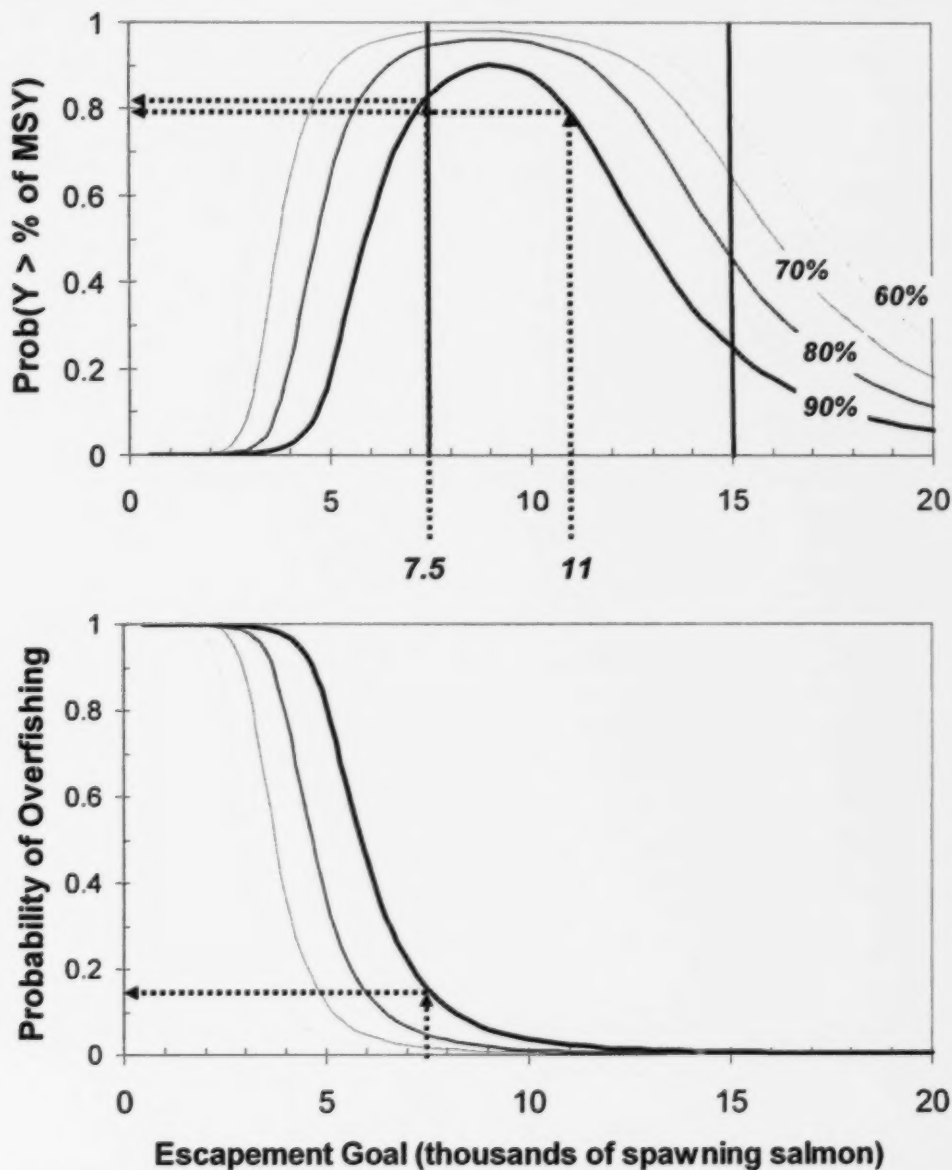
Figure 3. Upper Panel: optimum yield (OY) profiles defined as probability of at least Y percent of maximum sustained yield (MSY) at potential escapement goals for the Klukshu River stock. Shown are profiles for 60%, 70%, 80% and 90% of MSY. Dashed vertical lines on the 90% OY profile connect the range of escapements (7.5 to 11 thousand) that provide 90% percent of MSY with probability 0.87. Solid vertical lines show escapement goal (7,500 to 15,000) proposed by Clark and Etherton (2000). Lower panel: overfishing (OF) profiles defined as the probability of having less than Y percent of optimum yield through recruitment overfishing at that escapement level. Shown are profiles corresponding to 60%, 70%, 80%, and 90% of MSY.

CONCLUSIONS AND ADVICE

The Bayesian statistical analysis, used to develop estimates for harvest, in-river run size, harvest rates, and escapements for calendar years 1976 through 2008, for the Alsek and Klukshu Rivers is comprehensive and robust in providing escapement goals and point estimates of *Smsy*.

The analysis of data resulted in a posterior distribution for *Smsy* with a mean 29,710 and a median of 28,190 for the Alsek River. Posterior distributions for *Smsy* for the Klukshu stock had a mean of 9,727 adults and a median of 9,102 adults. The analysis takes advantage of a longer time series of catch and escapement data than was previously available, as well as informative data provided by mark-recapture studies.

The analysis takes into account and incorporates known sources of uncertainty. A range of optimal escapement goals, based on 60%, 70%, 80% or 90 % probability of achieving *Smsy*, is provided. Overall, this analysis represents an improvement over methods used previously to determine escapement goals for these stocks and is endorsed for the provision of advice for the establishment of escapement goals for the Alsek and Klukshu Rivers.

OTHER CONSIDERATIONS

Data sources, methods and results reviewed though this Canadian Science Advisory Secretariat Regional Advisory Process are based on the work published by the Alaskan Department of Fish and Game.

SOURCES OF INFORMATION

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Pacific Regional Advisory Process of October 18-19, 2010 on Assessment of Escapement Goals for Alsek River Chinook and Sockeye and Taku River Chinook and Coho. Additional publications resulting from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Eggers, D. M. and D. R. Bernard. 2011. Run reconstruction and escapement goals for Alsek River sockeye salmon. Alaska Department of Fish and Game, Fishery Manuscript Series No. 11-01 Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FMS11-01.pdf

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